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A Green Lean approach to global competition and climate change in the agricultural sector – A Swedish case study

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ABSTRACT

Increased global competition in the agricultural sector is rapidly changing the structure of farms and farming. As the number of small and diversified farms (often family-owned) decreases, the number of large and specialized farms (often corporate-owned) is increasing. In this transformation, the agricultural sector is more and more concerned with strategy, innovation, and competition in the effort to be more productive and more profitable. At the same time, the sector faces demands that it become more environmentally responsible in its policies and practices. This paper proposes a Lean Implementation Framework that small and mid-size farms can use as they aim to increase production and profit and yet support environmental sustainability. This case study takes an action-oriented research approach that focuses on the implementation of a Green Lean approach at 34 Swedish farms using various Lean tools. The paper describes how training sessions, farm visits, workshops, and counseling were used to introduce the farmers to the benefits and risks of the implementation of a new business model that added Green elements to the traditional business model design. The paper concludes with recommendations for adaptations to the Framework and suggestions for future research.

1. Introduction

In the agricultural sector, as in many other sectors, increased global competition has resulted in a movement to large-scale production, greater use of standardized technology, and more organizational and managerial innovations. For several decades, the industrialization of agriculture has driven this worldwide development. The tools of agricultural industrialization are specialization, formalization, and standardization, all of which link to the trend toward fewer and larger farms. Associated with this development is the growing awareness that agricultural production may negatively affect the world's climate, not least because of greenhouse gas emissions from the production of milk and meat (Kimming et al., 2015; Winkler et al., 2016).

Given this emphasis on greater productivity and profitability, the agricultural sector must adopt a more strategic, innovative, and competitive outlook that also recognizes the potentially harmful environmental effects of some farming practices. Barth et al. (2017) concluded that many business models in the agricultural sector have focused primarily on profit when, in an increasingly competitive environment, business models focused on sustainability are needed. One proposal is to combine Green and Lean principles, practices, and tools in ways that can increase business competitiveness and that can also benefit the environment. Dües et al. (2013) advanced this idea in their article titled "Green as the new Lean". According to these researchers, Lean can be the catalyst for greening companies. King and Lenox (2001) concluded that Lean thinking will have a spill-over effect on existing Green practices.

In recent years, various industries and sectors have adopted Lean production or Lean manufacturing (often referred to simply as "Lean") as a method to increase companies' and organizations' efficiency. Lean has migrated from its use in production processes to other areas such as the service sector (Abdi et al., 2006; Piercy and Rich, 2009; Swank, 2003), administrative processes (Atkinson, 2004), healthcare (Brandao de Souza, 2009; LaGanga, 2011), and public administration (Arlbjørn et al., 2011; Pedersen and Huniche, 2011).

Lean is also increasingly used in the agri-food sector. In a pioneering article, Simons and Zokaei (2005) reported on the use of

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Lean in the UK red meat industry. They demonstrated the benefits of Lean production in a value chain analysis that responded to consumer demands. Perez et al. (2010) conducted similar research in the Catalan pork sector. Henchion and McIntyre (2010) studied Lean in the Irish beef industry. However, it seems that Lean has not been studied at the individual farm level in Sweden or elsewhere.

The main objective of this paper is to propose a Lean Implementation Framework for the agricultural sector that includes Green elements. This Framework, which was adapted from the Swedish manufacturing industry to fit the agriculture industry, illustrates how to implement Green Lean practices and tools in farming activities. The rest of the paper is structured as follows. Section 2 presents a contemporary literature review. Section 3 describes the EU-funded analytical project for Lean agricultural production and presents the Lean Implementation Framework. Section 4 describes the research methodology. Section 5 presents the case study results from the use of the Framework at 34 Swedish farms. The discussion and conclusions from the case study are presented in Sections 6 and 7, respectively. Section 7 also offers suggestions for future research.

2. Literature review

This section presents a contemporary literature review of an integrated approach to Green and Lean (referred to as Green Lean) preceded by a discussion on the concept of Lean.

2.1. The concept of Lean

As a concept, Lean originated in the Japanese auto industry with the Toyota Production System (TPS) that promotes flexibility in production. The main objective of TPS is cost reduction achieved through quality control, quality measurement, and improvements in the work environment (Womack et al., 1990). According to Hayes (1981), the focus of Lean is constant minimization of waste in work and continuous improvement of work through adding value. Liker (2004) and Lewis (2000) argued that the focus in Lean production should be the entire product value chain. This focus can lead to evaluations aimed at eliminating waste and making improvements.

Lean implementation is a critical issue in adopting Lean production (which is the Western version of TPS). Some commentators on Lean have focused on Lean implementation (e.g., Chicks and Cox, 2005; Hallam and Contreras, 2016). According to Cannon and Edmondson (2005), Lean implementation requires an entirely new way of thinking in everyday work. Successful Lean production requires that managers and employees are actively engaged in the implementation. This often involves changes in behaviours and attitudes. Yadav et al. (2017) concluded that Lean implementation is a transformational process that requires organizational support. Bhasin and Burcher (2006) argued that a Lean program may fail if the adopting organization views Lean as a specific program rather than as a life-long program in which the Lean philosophy permeates all activities and decisions. Jack et al. (2014) reached a similar conclusion based on their survey of how innovation and technology adoption in the agri-food sector influence education and skills requirements.

> Training to deliver on these new business objectives included elements of developing interpretative, analytical and decision-making skills associated with the management of new production techniques and procedures. (p. 278)

The Lean literature also addresses current and proposed frameworks that describe Lean principles and Lean implementation tools. Belhadi et al. (2017) argued that existing frameworks, which derive mostly from the experiences of large companies, do not consider the specific characteristics of small and medium-sized companies. Yusof and Aspinwall (2000) claimed that financial and personnel constraints disadvantage small and medium-sized companies when they try to adopt change initiatives. They argued that such companies (e.g., small agriculture companies with fewer than ten employees) are unable to imitate the Lean change tools used by larger companies.

2.2. The concept of Green Lean

In recent years, the term “Green Lean” has been used to link Lean production to sustainable Green development. Green Lean describes the processes intended to improve operational efficiency and environmental sustainability and to deliver economic and social value to customers and society. Various studies have linked “Green” with “Lean” in an effort to explain how businesses can advance both productivity and profitability through use of Green measures (Caldera et al., 2017; Cherrafi et al., 2017; Garza-Reyes, 2015; Sartal et al., 2018).

Garza-Reyes (2015) made a systematic literature review of 59 articles published between 1997 and 2015 that discussed the Green Lean approach. He concluded that sustainable initiatives must be aligned with more traditional priorities such as profitability, efficiency, and customer satisfaction. The conceptual and empirical studies identified in this review mainly address the synergies, convergences, and divergences between Green and Lean.

Most Green Lean research has been conducted in sectors other than the agri-food sector. Caldera et al. (2017) reviewed the implementation of Green and Lean initiatives and sustainable business practices as described in 33 theoretical articles and 69 empirical articles. The empirical articles were mainly automotive or other manufacturing cases studies. Of the few studies of Green Lean in the agricultural sector, one study is notable. Folinas et al. (2013), who explored Value Stream Mapping (VSM) as an effective and efficient improvement tool, included its use in “greening” the agri-food supply chain.

The Green Lean research concludes that the use of Lean methods seems to have a positive influence on environmental performance. These methods include 5S, Cellular Manufacturing, Lean Supply Chain Management, Total Productive Maintenance, and Value Stream Mapping. Caldera et al. (2017) presented a quadrant framework of Lean and Green themes from their review of the literature. Garza-Reyes (2015) proposed the integration of Green Lean with Six Sigma. Pampanelli et al. (2014) described a Lean framework in which environmental sustainability is integrated with Lean thinking in a way intended to use resources more efficiently.

Sartal et al. (2018) evaluated the environmental effects of Just-in-Time, Jidoka, Lean Manufacturing, and Respect for People (RfP) by taking a shop-floor perspective. This research was based on a 9-year study with 5672 observations. The researchers found that the relative success of Lean methods should be evaluated because some Lean methods are not “ecofriendly”. They found that only Jidoka and RfP had a positive environmental effect. They write: “In ‘low-lean’ environments, each lean improvement has a high impact on environmental performance, but this influence will decrease, and almost disappear, as the firm becomes leaner” (p. 368).

The main conclusions from this research are several. First, as Bergmiller and McCright (2009) concluded, the two concepts (Green and Lean) are compatible and synergistic. Second, Green and Lean approaches can be effectively combined in Lean frameworks (Cherrafi et al., 2017; Garza-Reyes, 2015). Third, there is scant empirical research on how Green Lean can be successfully implemented (Cherraffi et al., 2017; Sartal et al., 2018).

3. The analytical project for Lean agricultural production

A national project Sweden titled *Lean Lantbruk* (translation: Lean Agriculture) was introduced in 2010. Lean Agriculture promotes the idea that Toyota's Lean production philosophy can be transferred from the manufacturing sector to the agricultural sector. The goal of the project was (and is) to provide support for farmers in Lean training over a period of 18 months. The specific objectives of the project are to increase farmers' profitability, resource efficiency, and competitiveness, and to support farm growth. Since its inception, approximately 100 farms engaged in various activities have participated in the project. The 34 farmers in this case study were drawn from this project.

Fig. 1 presents the Lean Implementation Framework used in this study. For a description of the program as used in the Swedish manufacturing sector, see Assarlind (2015).

3.1. Pre-implementation phase (4 weeks)

3.1.1. Motivational meetings and registration

The farmers were invited to seminars or lectures on Lean thinking that were usually arranged with local stakeholders or with experts at regional or national agricultural conferences. The purpose of the seminars and lectures was to share knowledge and experiences about Lean with the farmers and to spark their interest in Lean so they would register for the Lean Implementation Framework program that is the focus of this case study.

3.1.2. First visit to the farms

After a farm owner indicated an interest in the program, a program representative visited the farm in order to interview the farm owner and employees. The representative used a questionnaire to learn each farm's production type, production volume, and organizational structure. The questionnaire also established the farmers' understanding of the Lean philosophy, the program's purpose, and their interest level in the program.

3.1.3. Study visits

After the acceptance of a farm into the program, the farmer, the farm manager, and a Lean Coach made a study visit to a manufacturer that used Lean. After the manufacturer's Lean coordinator described how the company used Lean, the group toured the production facilities. After the tour, the group discussed what they had seen and learned.

3.1.4. Management training

Farm owners and managers attended a two-day management training session that focused on Lean leadership, the Lean tools, principles, and philosophy, and the concept of change management. The training session used Liker's 14 Lean management principles and the leadership philosophy called “The Toyota Way” (Liker, 2004). One half-day of the training was spent in the “Buckingham Lean Game”, a Lean simulation game on waste elimination (Bicheno, 1995). During the training session, the participants began to plan the implementation of Lean at their farms by considering their priorities, objectives, and the Lean work roles. The participants were asked to explain the Lean philosophy to their employees on their return to the farms and to schedule Lean meetings.

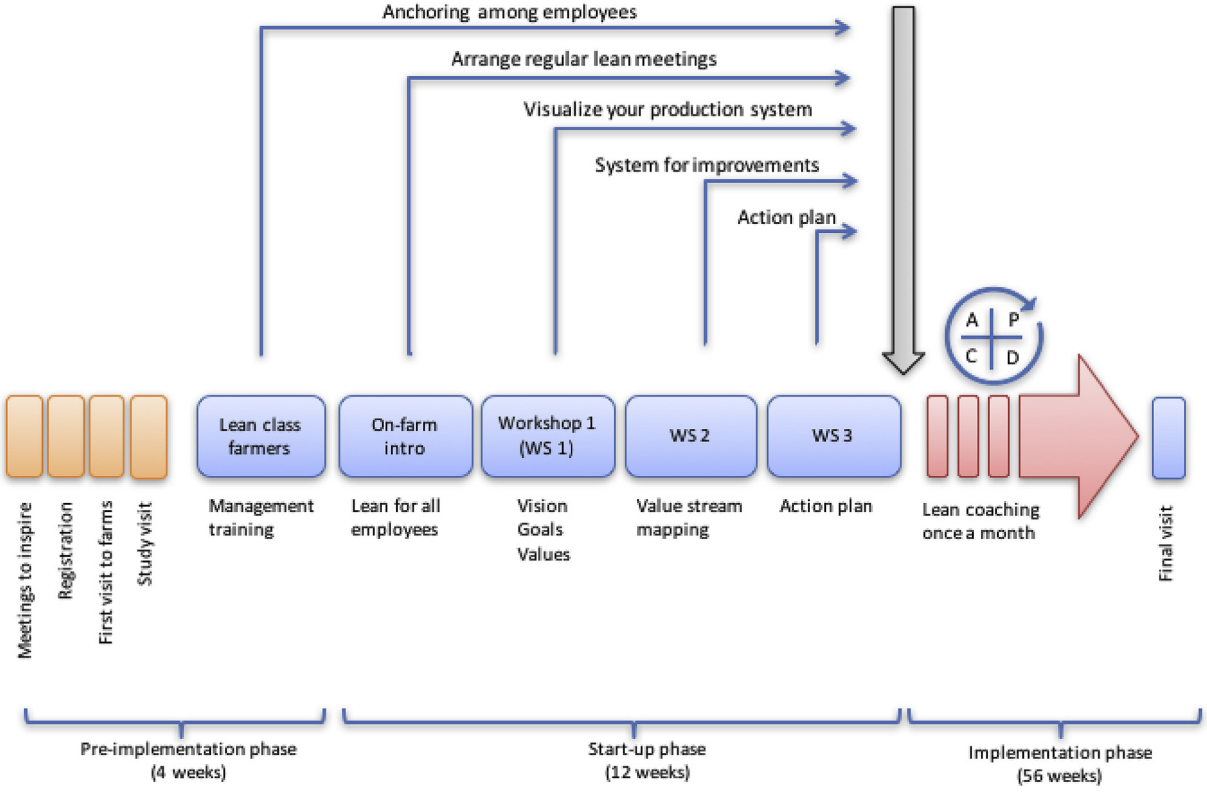

Fig. 1. The Lean Implementation Framework. The colour scheme for the modules is as follows: introductory activities (orange), education and workshops (blue), and coaching sessions (red). The arrows indicate the tasks assigned to the farmers as “homework”. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

3.2. Start-up phase (12 weeks)

3.2.1. On-farm introduction

At the on-farm visit, led by a Lean Coach, the aim was to educate the program participants in the basic Lean philosophy. The participants received study materials on Lean's history, tools, principles, and philosophy. These materials featured numerous photographs of farms where Lean had been successfully implemented. Additional instruction in the Lean tools, principles, and philosophy was also offered.

The Workshops: Three half-day workshops, led by a Lean Coach, were organized for the participants. They had "Homework" assignments to be completed between the workshops.

3.2.2. Workshop 1: visualization of a production system

Workshop 1 emphasized the importance of having a positive view of Lean, of understanding customer demand, and of delivering customer value. A key principle of Lean is that waste should be minimized by reducing non-value adding activities. By the conclusion of Workshop 1, the participants should have acquired a clear grasp of a production system that reflected the farm's values, vision, and goals.

3.2.3. Workshop 2: system for improvements

Workshop 2, which was informally structured to encourage discussion, taught the participants Lean production processes, showed them how to identify waste areas, and introduced them to a preliminary system for work improvements. The participants identified their on-farm value streams using Value Stream Mapping (VSM) to discover waste areas, especially environmentally harmful waste areas resulting from sub-optimal resource use. Although the sub-processes differed among the production types, a pattern between farms with the same production type was identified. Fig. 2 presents the results of the VSM for dairy production.

3.2.4. Workshop 3: action plan

Workshop 3, which built on the waste areas identified in the VSM, illustrated the action plan needed for choosing the Lean tools and for planning the Lean implementation. Implicit in the action plan was the idea that non-value adding activities should be minimized (Arlbjørn et al., 2008). The participants selected the tools (from approximately 18 available Lean tools) most likely to have the most positive effect on production. The Lean Coaches recommended tools that could accomplish Lean work "by the book" (i.e., according to theory). By the end of the Workshop, each farm had an action plan (i.e., a strategic process for Lean). Although the Lean implementation was the same for all farms, each farm had an action plan that allowed for flexibility in the choice of tools.

3.3. Implementation phase (56 weeks)

3.3.1. Coaching once a month

In this phase, the Lean Coaches provided monthly coaching sessions for the program participants. The purpose of this phase was threefold: 1) to implement appropriate Lean tools; 2) to evaluate the action plan; and 3) to establish a system for long-term change. The farmers and various farm employees attended the coaching sessions that took an experiential learning approach following Deming's PDCA Cycle (Plan-Do-Check-Act). The farmers and the Lean Coaches jointly chose the Lean tools. The sessions, which were conducted in modules (following a schedule prepared in Workshop 3) had a standard, documented workflow and used training materials. One module, for example, dealt with the standardization of work using 5S, the Japanese workplace organization method (in English, 5S can be translated as sort, straighten, shine, standardize, and sustain).

3.3.2. Network meetings

The farmers and their employees met in small groups on three occasions to discuss a production problem or issue. For example, a production or leadership problem or an organizational issue at the host farm was discussed. Using the A-3 method (a Lean problem-solving and continuous approach) and Deming's PDCA Cycle, the participants tried to find a solution. A Lean Coach was the discussion facilitator.

3.3.3. Final farm visit

At the last coaching session at the final farm visit, key production indicators were used to evaluate each farm's progress in the Lean Implementation program. Plans for future Lean programs were discussed.

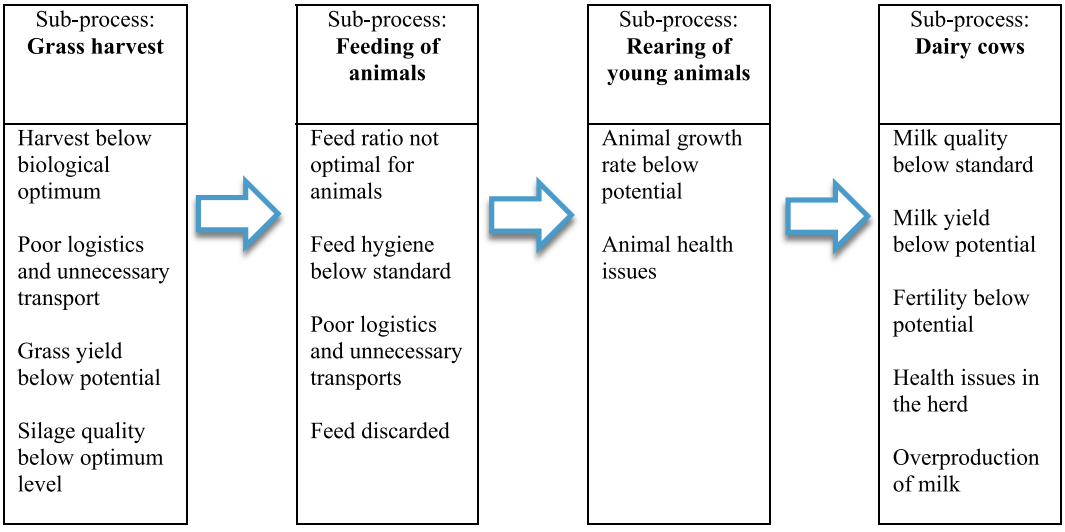

Fig. 2. VSM Mapping: Low resource efficiency results in waste in the sub-processes of dairy production, creating negative environmental effects at Swedish dairy farms.

4. Methodology

Action research and interactive research methods (Aagaard Nielsen and Svensson, 2006) were used in this study. Thirty-four farms in south-western Sweden that specialized mainly in dairy, crops, poultry, pork or beef production, and other products took part in the study (Table 1). Some farms also had forestry, construction, or contract operations. All farms were participants in the Lean Agriculture (*Lean Lantbruk)* project funded by the European Social Fund and directed by agricultural consultants.

The farm owners and managers attended regional meetings that described the objectives and the structure of this study. After these introductory meetings, the farmers could apply to the Lean Implementation Framework program. Lean Coaches visited the farms to reconcile the farmers' expectations with the goals and objectives of the program and to confirm the farmers' participation in the research. To qualify for the program, the farmers had to have at least two employees and pay a fee of 5000 Euros.

Primary data were collected in interviews and observations. A qualitative research approach was used to analyze the data. Secondary data came from the Lean Coaches' diaries and other program documents (Table 2). Prior to the interviews, a case study protocol was prepared for each farm with general farm information (production, owners, and employees) and the context/status of its Lean implementation. These protocols were completed at farm visits in the pre-implementation phase of the program. The farmers' reasons for interest in the program and their expectations of the program (in addition to their business challenges) were in focus throughout the data collection.

The data analysis began with a review of the Lean Implementation Framework as adapted for the agricultural sector. The Lean Coaches instructed and guided the farmers.

A semi-structured interview guide was used for the interviews (Bryman, 2003). These interviews lasted for a minimum of 30 min each. All interviews were audio-recorded and subsequently transcribed. The researchers also took notes during the interviews. A focus group meeting and learning seminars were held. The Lean Coaches were interviewed at the end of the program.

The farmers were interviewed at three timepoints: before the program, during the program, and after the program. Before the program, the farmers were interviewed for program eligibility, expectations, and interest. During the program, the farmers were interviewed about the theoretical and practical aspects of the program, their business challenges related to Lean, and the workshop and seminar follow-ups. After the program, the farmers were interviewed about the program procedures and results, including an evaluation of the Lean Coaches. At this timepoint, 16 of the 34 farmers prepared a Lean audit in which they described various outcomes from the Lean Implementation program.

In all interviews, the emphasis was on three critical management areas in Lean implementation (Belhadi et al., 2017). These areas are the CEO/farmer (learning assessments, management, leadership, networking, and challenges), employees (competence development, engagement, participation, and use of new techniques and tools), and the business (challenges of competition, performance, efficiency, and productivity).

The Lean Coaches and the program leader held monthly telephone conference meetings to discuss the program. The paper's authors were parties to these meetings. The Lean Coaches documented their visits to the farms in diaries. Content analysis (Lacy et al., 2015) was used to analyze the transcribed interviews, notes, observations, and diaries.

The Appendix lists the Lean tools, principles, and philosophy used at the farms. The listing was compiled based on interview data from the farmers and the Lean Coaches and from researcher notes and meeting observations. The extent of tool use is ranked on the following scale: (1) not at all; 2) to a certain degree; (3) to a large degree. The same scale was used to rank Green practices (e.g., the integration of Green and Lean initiatives).

Table 1
The main products and number of employees for the 34 farms in the study.

Main product	No. of farms	No. of employees
Dairy	20	2–12
Meat	11	3–8
Crop/vegetables	3	8–18
Total	34	

Table 2
Empirical data collected from various sources and on various occasions.

Data collection method	No. of occasions
Case study protocols and monthly documentation of program process	34
Mid-point and final interviews with farmers	34
Lean audits on farms at the end of the program	16
Biweekly webinars with Lean Coaches	13
In-depth interviews with Lean Coaches at the end of the program	7
Coaches' diaries from farm visits	24
Focus group meeting with steering committee and learning seminars with committee members	2

5. Results

5.1. The use of Lean tools and their effects

The modules in the Lean Implementation Framework (Fig. 1) are based on commonly used Lean tools, principles, and philosophy. The most-used tools in this program were the following: 5S, standard operating procedures, and the visualization boards (Appendix). The farmers used these tools to manage routine work processes such as milking cows, feeding animals, maintaining vehicles and equipment, cleaning the workplace, and standardizing the placement of materials and equipment. Many of the 16 farmers who prepared the final Lean audit reported positive effects on the workplace structure and workplace environment. They said they used these tools to reduce the time searching for tools and materials, to make the workplace safer, and to improve routines for waste disposal and recycling. Several farmers also observed that an improvement in work structure increased efficiency in the use of resources. For example, fertility and growth rates increased when the care and management of cows and heifers improved.

Bicheno (2004) lists seven types of manufacturing waste: transport, inventory, motion, waiting, over-processing, overproduction, and defects. The agricultural wastes observed most frequently in this program were transport, inventory, motion, and defects. Other wastes were greenhouse gas emissions, excess diesel fuel consumption, and feed spillage.

Some changes needed to reduce the negative effect of waste areas at the farms were practically and easily introduced. For example, with the new routines for checking the grain levels in the feed silos, feed shortages were less frequent. On several farms, the implementation of simplified routines and standardized work procedures for calf rearing, milking, stalls cleaning, and animal health checks had a positive effect on animal health and performance.

The Green Lean tools (i.e., initiatives) also revealed positive environmental (or “greening”) effects (Table 3). For example, the farmers and employees took “waste walks” in which they identified

Table 3
The Lean audit results: Evaluations of improvement effect by 16 farmers in the program.

Areas that have improved	Examples of improvements	Positive effect	No/negative effect
Resource efficiency	o Improved udder health of cow o Better precision in feeding of animals o Improved calf health o Improved growth of animals o Better fertility rates o Reduced age at first calving o Increased milk yield	14	2
A more structured workplace	o Less time spent on searching for tools o Better planning of daily work due to the use of whiteboards o A more proactive workforce	15	1
Teamwork	o Improved communication in the group o A shared vision and common goals	11	5
Leadership	o More feedback to employees o Employees self-directed to a greater degree o Daily management is easier	11	5
Employee engagement	o Employees see the whole picture o Easier to recruit new employees	12	4
Change and innovation	o More focus on problem solving o Good ideas are documented o A different way of thinking o Easier to implement changes	13	3
Productivity (working hours/product)	o More time to do maintenance work o Fewer hours, increased volume, and maintained product quality	13	3
Product quality	o Better and a more even product quality	15	1
Workplace environment	o Work is less stressful o Improved safety at work o A more even work load, with some individuals noticeably less exhausted	14	2
Customer focus	o Better customer offers in the farm store o Deliver to customer demands o Organization of open farm days	5	11
Other	o The bank positive to the Lean program o Increased gender equality on the farm	3	13

work safety problems and observed various examples of waste including the waste of energy, water, and human resources. A spaghetti diagram was used to present the flow, distance, and waiting times for on-farm transportation in an effort to reduce the transport time for animals, feed, and other materials by heavy, greenhouse gas emitting vehicles. At one farm, a heavy loader had to be driven six kilometres, several times a day for the distribution of cattle feed. Improvements in the locations of feed storage silos could reduce the use of diesel by about 50%. Such improvements in the bulk storage of seeds and fertilizers seeds were also possible in crop production.

Furthermore, greenhouse gas emissions from dairy production decreased with the reduction in the first calving age. With this practice, less feed is required and methane production from metabolism decreases. Although not calculated in this study, calculations by *Greppa näringen* (2013) [1] show that a typical Swedish dairy farm (with 80 cows) can reduce its annual CO_2 equivalents by 15 tons if a cow has her first calf at around two years of age. In addition, emissions of phosphorus and nitrogen in animal manure decrease if feed efficiency increases. The surplus nitrogen is excreted to the urine as volatile nitrogen that easily disappears in air and water without harmful environmental effects.

In general, after the Lean implementation, the farmers paid more attention to safety issues in the work environment. For example, with the use of 5S, the participants noted specific safety problems. They realized that employees who used disc grinders should wear a lanyard when working at elevated levels. Employees who had to push wheelbarrows up slippery feed mangers when door handles were broken were at increased risk of injury. As Reynolds et al. (2013) found, the agricultural sector consistently ranks as one of the highest of all injury risk industry sectors.

Some farms, which had only begun the Lean implementation, adopted tools such as Single Minute Exchange of Die (SMED) and Total Productive Maintenance (TPM) (see Bicheno, 2004). However, they had not yet fully implemented these tools. SMED was used successfully to decrease changeover time, for example, between batches in pork production, and between cleaning periods for milking equipment in dairy production. These changeover steps could be performed while the processes were in operation. TPM was used to focus on machine breakdown follow-up, to visualize planned services, and to educate machine operators on preventive maintenance work. Several farmers introduced systems and visualizations for following-up on the maintenance of tractors and other machinery as a way to avoid breakdowns. More experienced and skilled employees trained their colleagues in maintaining equipment.

The use of TPM produced other successful outcomes. For example, when the feeding system in a pig barn function correctly, less feed is wasted. As Cederberg et al. (2009) calculated, half the greenhouse gas emissions from pig barns are from the production of feed. Improvements in the manure scrapers in the cow barns resulted in cleaner and drier floors, which likely would improve the health of the cows' hooves. Standardized routines for filling the tractor with diesel would reduce standstill times and therefore fewer greenhouse gas emissions. A visualized system showed that feeding calves in sheds rather than in outdoor racks was more efficient. Improved routines for checking temperatures in the chicken coops would save energy. Better equipment storage and maintenance procedures means fewer breakdowns.

The use of the Value Flow Analysis helped the farmers identify

[1] *Greppa näringen* is a Swedish service that provides counseling on environmental benefits in agricultural activities. It is a collaboration between The Swedish Board of Agriculture, The Federation of Swedish Farmers, and county administrative boards.

Table 4
Lean tools offered by *Svenskt Sigill* and Focus on Nutrients.

Lean tools	Services offered by *Svenskt Sigill* (Swedish Seal)	Services offered by Focus on Nutrients
Waste walks	Templates for identifying waste in animal and crop production	Advice on feeding ratios and crop nutrient requirements.
5S	No activity	Systematic improvement in the workplace environment
Standardized work	Climate certification when meeting certain criteria	No activity
Value Flow Analysis	Advice on analysis of energy use	Calculations on greenhouse gas emissions and analysis of energy use on the farm
TPM	No activity	No activity
Visualization boards	No activity	No activity
Logistic analysis with spaghetti diagram	Green driving tips	Logistic analysis when planning for new buildings, and green driving tips for farmers
Continuous improvement with A3 and PDCA	No activity	No activity

waste, envision an improved situation, and identify a list of needed improvements. Farmers who grew crops realized that the Value Flow Analysis generated ideas on how to optimize the spread of commercial fertilizers and manure in the fields, how to reduce energy consumption, and how to apply just-in-time inventory routines.

5.2. Linking Lean to other Green initiatives

The Lean Implementation Framework can also create synergies with existing best practices mediated by Green initiatives that decrease negative environmental effects from agricultural activities. The Framework supports Pampanelli et al.'s (2014) argument that the linkage between Green and Lean thinking (in manufacturing) means this linkage may be integrated and managed jointly.

In Sweden, the aim of two Green initiatives, which are directed at farmers, is primarily to reduce greenhouse gases resulting from agricultural activities. One initiative is the climate certification seal (*Svenskt Sigill)* that is awarded to farms that try to reduce such emissions and that promote climate-friendly food products. Climate certification "focuses on reducing climate impact, but there are also other positive results, such as reduced eutrophication, increased biodiversity and sustainable energy systems" (*Svenskt Sigill*, 2018).[2] Climate certification is intended to encourage the use of best practices in animal welfare, the optimal use of fertilizers, and more efficient use of finite resources. These aims are consistent with the aims of the Lean Implementation Framework.

A second Green initiative in Sweden is the Focus on Nutrients program that supports farmers with knowledge and tools they can use "to implement cost-effective environmental and climate measures".[3] The mission of Focus on Nutrients is, among other things, to reduce the loss of nutrients to air and water from livestock and crop production and to reduce the harmful effects of pesticides and greenhouse gas emissions. Focus on Nutrients offers education programs and on-farm advisory visits.

Table 4 lists the tools offered by these two Green initiatives. Consistent with Green Lean practices, both initiatives emphasize the elimination of waste, Value Flow Analysis, and Logistic analysis. The idea of workplace certification with the use of the 5S tool is also similar to the certification process in the Lean Implementation Framework. The idea of workplace certification with the use of the 5S tool is similar to the certification process in the Lean Implementation Framework related to Green Lean practices. However, the Green initiative tools also differ from Lean Implementation tools. For example, two Lean tools are Visualization boards and Continuous improvement. *Svenskt Sigill* and Focus on Nutrients do not support these tools.

5.3. Evaluation of the Lean Implementation Framework program

The farmers and their employees were trained in the use of A3 with the PDCA Cycle. Only 17 of the 34 farms, however, used the A3 tool on a regular basis and on their own initiative. In the final analysis, the farmers concluded that the tool, with its extensive documentation, was too time-consuming. However, during the implementation period, with the support of a Lean Coach, a number of improvements were systematically implemented following Deming's PDCA Cycle.

Success with the Lean Implementation Framework is conditional on the users' commitment to the concept of Lean. It was a challenge for the farmers to combine program-based Lean implementation with strategic Lean leadership in which there is a greater focus on long-term organizational development. The farmers and their employees were always occupied with daily activities and with various on-going programs (e.g., expansion, construction programs, and farm shops). They complained that the program introduction and the workshop activities took too much time. To some extent, they thought the program was just another program among many others.

The farmers and their employees were more supportive of their training in visual management. The Lean Coaches organized this training by conducting visualization board (i.e., "whiteboard") meetings that focused mainly on daily planning, work task allocation, follow-up on improvement work, and the purchase of consumable goods. The aim of these meetings was to improve the information flow and to review communication results. A majority of the 16 farmers who completed the Lean audit reported their communication systems had improved. They found the informal visualization boards preferable to regular workplace meetings for communications.

6. Discussion

Previous research claims that the use of Lean improves production efficiency and reduces harmful environmental effects (Bergmiller and McCright, 2009; Pampanelli et al., 2014). A number of Lean implementation frameworks or models, which emphasize different features of the Lean concept, are structured for various industries (Assarlind, 2015; Belhadi et al., 2017; Bicheno, 2004; Yusof and Aspinwall, 2000). Some frameworks and models take both a Green and a Lean perspective (Dües et al., 2013; Pampanelli

[2] *Svenskt Sigill* (Swedish Seal) is a quality label for Swedish food and flowers. Farmers certify their products according to the standard known as IP SIGILL.

[3] Focus on Nutrients is a joint venture by The Swedish Board of Agriculture, The County Administration Boards, The Federation of Swedish Farmers, and a number of agri-food companies.

et al., 2014).

This study presents a Lean Implementation Framework for the agricultural sector that primarily aims to achieve profitable and sustainable production through the use of standard operating procedures, the elimination of waste, the increase in value-adding activities, and the commitment of farmers and their employees to change work. The Framework also has Lean and Green elements that produce spill-over environmental benefits.

An example of these benefits is found in dairy production where a number of activities in the main sub-processes produce significant quantities of greenhouse gases (Melin et al., 2013). Dairy farmers need systems that minimize the emission of such gases while ensuring the health and productive capability of their herds. The success of such systems depends on proper animal husbandry, standardized routines, and the commitment of well-trained employees. In this study, the use of Lean in the dairy (and other) production processes helped establish and maintain such systems.

Although this study does not quantify the reduction of greenhouse gas emissions on farms following Lean, it supports other studies' conclusion that the use of Lean can produce environmental benefits. This study takes a qualitative approach in reaching this conclusion from program participants' interviews and reports.

This study explored the potential synergies in the agri-food industry between Lean and two Green initiatives. Although Lean, unlike Green, emphasizes organizational learning, management, and continuous improvement, the analysis of data in this study nonetheless shows that some Lean tools have functions that are quite similar to the services provided by the two Green initiatives. A synergistic combination of Lean and Green can produce environmental benefits at the same time it produces economic benefits. One of the most valuable tools in the combination of Green and Lean is the Value Stream Mapping tool that can be used to quantify the carbon footprint of the production processes. Such mapping of carbon emissions in various sub-processes can help farmers work more strategically to reduce their farms' negative environmental effects.

The Lean Coaches were an essential feature of the Lean Implementation Framework program in their role as program guides and instructors. This was a role that required close interaction with program participants. The Lean Coaches established coach–farmer relationships characterized by mutual trust, honesty, and empathy. The Lean Coaches also facilitated the farmers' acceptance and use of more sustainable, best management practices (see Ingram, 2008).

The focus in the three Workshops in the Lean Implementation Framework was to explain the Lean tools, principles, and philosophy. These elements, when understood and used jointly, can result in long-term changes with beneficial effects. Thus, the Framework is more a general guide than a stepwise "how to" description of Lean implementation in the agricultural sector.

The Lean Implementation Framework has adaptive potential for other industry sectors. For dissemination to sectors unfamiliar with industrial management concepts (e.g., Lean), close attention should be paid to the motivational activities in the pre-implementation phase. The implementation phase that emphasizes experiential learning is likely to appeal to professionals who prefer hands-on initiatives to change initiatives driven by abstract models.

Program design modifications may be advisable in adaptations of the Lean Implementation Framework. Some modules might be more effective if their time frames were reduced (e.g., the 12-week timeframe for the Workshops). It may be ineffective to overemphasize the "Lean toolbox" approach (as described by Arlbjørn et al., [2008]), that tends to result in fragmented interventions. Following social learning theory (Bandura, 1986), the Framework might benefit from more development of participants' learning in group and individual coaching. This could be accomplished by organizing periodic Lean Coach sessions with groups of four to five farms.

7. Conclusions

The Lean Implementation Framework described in this study can enhance production efficiency and thereby contribute to more sustainable food production with the use of various Lean tools such as organizational learning and continuous improvement. The majority of the farmers in the program observed positive effects on their productivity, product quality, and work environment.

The study also revealed the potential for synergies between Lean and two Green initiatives in Swedish agriculture. If these synergies are supported, the agricultural sector may be more receptive to change programs when shown how Green and Lean can combine to promote sustainable economic profit and sustainable environmental benefit. The study showed that the facilitative approach taken by the Lean Coaches led to greater interest in responsible and sustainable agricultural practices.

The farms in this study are businesses that have been family-owned and family-managed for years. Typically, these farmers have a mindset shaped by the collective family tradition and culture required to operate such farms, generation to generation. The farmers are also proud of their stewardship ethic that commits them to the care and management of the land and of animal and plant life. For these reasons, the farmers are receptive to Green initiatives that sustain the natural environment.

Lean implementation involves empowering people as they acquire knowledge that they can transfer to action. Empowerment means change, and change is often difficult. In this study, the greatest program challenge was motivating the farmers to find time in their daily schedules for the Lean change initiative.

The following recommendations and avenues for future research are proposed.

First, In empirical research on Lean implementation, consideration should be given to the degree of "Leanness" of the studied organizations. According to Sartal et al. (2018), each Lean improvement has a high impact on environmental performance in "low-lean" environments, but this influence decreases as the firm becomes "leaner". For this analysis, longitudinal data are required. The focus on increased profitability is important in the short run, but from a strategic perspective, organizations require long-term, sustainable business models (Barth et al., 2017).

Second, more research is needed on how Green and Lean can be integrated in the agricultural sector. For example, using quantitative research methods, the reductions in greenhouse gases by farms that have adopted Green Lean could be measured.

Third, researchers might take an action research approach in which environmental specialists, Lean Coaches, and farmers cooperate in sustainable agricultural programs using Green Lean tools.

Such research need not be limited to the Swedish context.

Fourth, researchers might adapt (and test) the Lean Implementation Framework in response to the program criticism from the participants in this study. A re-design might abbreviate the timeframe for the Workshops, use more individual coaching, and organize small group meetings. Small-scale, preliminary (pilot) studies could investigate the modified Framework for feasibility.

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Appendix. Use of Lean tools, principles, and philosophy. Use of Green practices.

Lean at three levels: tools, principles, and philosophy (Arlbjørn and Freytag, 2013)	Levels used in Lean Implementation Frameworkis ○ = not at all, ◎ = to a certain degree, ● = to a large degree	No. of farms Implementing	Model includes Green practices ○ = not at all, ◎ = to a certain degree, ● = to a large degree
Tools			
Value stream mapping (VSM)	●	34	◎
5S	●	26	◎
Bottleneck and constraint management	●	34	◎
Information boards (and daily planning)[1]	●	21	○
Cause and effect analyses	●	34	○
Standard operating procedures[1]	●	27	◎
Waste walks	●	34	●
Single Minute Exchange of Die (SMED)	◎	1	○
Total Preventive Maintenance (TPM)	◎	12	○
Kaizen	◎	17	◎
Kanban	○	0	○
Pull	○	0	○
Group Layout	○	0	○
Takt time	○	0	○
Performance management	○		○
Demand smoothing (Heijunka)	○	0	○
Overall Equipment Effectiveness (OEE)	○	0	○
Principles			
Value from the customer perspective	●	34	●
Identifying process steps that add value	●	34	●
Making value-adding steps flow	●	34	●
Developing leaders devoted to the Lean philosophy[1]	●	34	◎
Only making what is pulled by the customer	○	0	○
Striving for perfection	○	0	○
Philosophy			
Reducing waste	●	34	●
Improving customer value	●	34	●
Long-term perspective[1]	○	0	○

[1] Not listed by Arlbjørn and Freytag (2013). Listed by Liker (2004).

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